INDOOR AIR QUALITY ASSESSMENT

Norton Municipal Center
70 East Main Street
Norton, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
June 2005

Background/Introduction

At the request of building occupants and the Norton Board of Health (NBOH), the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality concerns at the Norton Municipal Center (NMC), which includes the Norton Town Hall (NTH) and the Norton Fire Department (NFD), located at 70 East Main Street, Norton, Massachusetts. The request was prompted by concerns of potential mold growth, poor ventilation and lack of temperature control by occupants. On February 18, 2005, a visit to conduct an indoor air quality assessment was made to this building by Cory Holmes, Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Gary Covino, Health Agent for the NBOH, accompanied Mr. Holmes during the assessment.

The NTH is three-story building built in the early 1900's as a school (Picture 1). The first and second floors contain town offices and meeting rooms. The third floor is used for storage and the basement, which was formerly the Norton Police Department, is currently unoccupied. Town officials however, have plans to reoccupy the basement and/or use certain areas for storage of records. An addition was built in 1979 and contains the NFD (Picture 2). Portions of the NFD share rooftop ventilation equipment with the NTH.

Methods

MDPH staff conducted air tests for carbon dioxide, carbon monoxide, temperature and relative humidity with the TSI, Q-Trak, IAQ Monitor, Model 8551. MDPH staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The NMC has an employee population of approximately 35 and can be visited by up to 120 individuals daily. The tests were taken during normal operations. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 ppm (parts per million) in all areas surveyed, indicating adequate air exchange. Mechanical ventilation is provided by a heating, ventilating and air conditioning (HVAC) system, which consists of two rooftop air handling units (AHUs) ducted to ceiling-mounted supply and return vents (Pictures 3 through 6). This system was operating intermittently throughout the building on the day of the assessment. Thermostats control each AHU and have fan settings of "on" and "automatic". Thermostats were set to the "automatic" setting (Picture 7) during the assessment. The automatic setting on the thermostat activates the HVAC system at a preset temperature. Once the preset temperature is reached, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system.

The condition of the larger (and older) of the two rooftop AHUs appeared to be poor. The metal casing of the AHU was severely corroded, weathered and physically damaged (Pictures 8 through 10). The condition of the AHU is discussed in further detail in the Microbial/Moisture Concerns section of this assessment.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room, while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

Temperature readings in occupied areas ranged from 65° F to 79 ° F, which were just outside of the upper and lower boundaries of the MDPH recommended comfort guidelines in several areas. The MDPH recommends that indoor air temperatures be maintained in a range of 70 ° F to 78 ° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Temperature control complaints were expressed in a number of areas. Temperature control in the NTH is difficult due to the interior division of space into small offices and large open areas. For example the front section of the NTH that houses the Treasurer's Office is a former gymnasium with a ceiling approximately 30 to 40 feet high. In addition, the top part of the former gym was sectioned off into semi enclosed offices that are open to the large area that contains the Treasurers' Office (Picture 11). In contrast, occupants in the NBOH office, a small sectioned-off area, reported chronic heat extremes. In a few areas, air diffusers were blocked with plastic sheeting and duct tape (Picture 12) in an effort to control drafts. This alteration of the system, however, can throw the system off-balance and create uneven heating/cooling conditions in other areas adjacent to the blocked diffuser.

The relative humidity measurements in the building ranged from 22 to 29 percent, which were below the MDPH recommended comfort range in all areas surveyed the day of the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States. In contrast, relative humidity in excess of 70 percent for extended periods of time can provide an environment for mold and fungal growth (ASHRAE, 1989).

Microbial/Moisture Concerns

As discussed, the basement is currently unoccupied; however, town officials may renovate the space for future use. Wall materials in the basement appeared to be water damaged. Mold growth was observed on gypsum wallboard (GW) in the room adjacent to the former police photo lab (Picture 13). Carpeting in the basement also had a musty odor (Picture 13). Mold and related particulates can be irritating to sensitive individuals. In order for building materials to support mold growth, a source of moisture is necessary. Identification and elimination of water moistening building materials is necessary to control mold growth. No obvious source of plumbing leaks or water infiltration were identified. The most likely source of moisture in this area would be historically elevated relative humidity and condensation during summer months, due to lack of ventilation and temperature control. Porous materials (e.g., carpeting and GW) that are wetted repeatedly can provide a medium for mold growth. Mold, odors and related particulates can be irritating to sensitive individuals.

The US Environmental Protection Agency and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials (carpeting, ceiling tiles, etc.) be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

As previously noted in the ventilation section of this report, the casings of AHUs appeared damaged. A depression on the top of the large AHU in Pictures 4, 8 and 9, which appears to have been patched several times, is an indent into where rainwater accumulates. Accumulated debris (e.g., dust, dirt) was found inside the AHU cabinet (Picture 14). These materials can provide a medium for mold growth if it becomes wet. If these materials become colonized with microbial growth, spores can be distributed to occupied areas via the ventilation system.

Occupants in the Treasurer's Office expressed mold concerns regarding two black spots located in the corner of an interior wall approximately 15-20 feet high that were reported to be mold (Picture 15). Upon closer scrutiny, the black spots appeared to be holes in the wall in question. Corresponding holes that are located on the exterior wall directly opposite those on the interior were found by MDPH staff, indicating that these holes were likely made for utility pipes/wires (Picture 16). Damage to exterior wall plaster was also observed in several areas (Picture 17). Over time, these conditions can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through concrete and/or masonry (Lstiburek & Brennan, 2001). In addition, these breaches may provide a means of egress for pests/rodents into the building.

Several areas contained a number of plants. Plants, soil and drip pans can serve as sources of mold growth, and thus should be properly maintained. Plants should have drip pans to prevent wetting and subsequent mold colonization of window frames. Plants should also be located away from ventilation sources to prevent aerosolization of dirt, pollen or mold.

A number of areas had missing and/or water-damaged ceiling tiles in both the NTH and NFD (Pictures 18 and 19), which can indicate leaks from either the roof or plumbing system. Occupants reported that ceiling tiles became damaged as a result of condensation produced during hot weather by the air conditioning equipment. Water-damaged ceiling tiles can provide a source of mold and should be replaced after a moisture source or leak is discovered and repaired.

A number of areas had water coolers installed over carpeting. Water spillage or overflow of cooler catch basins can result in the wetting of the carpet. In addition, some of the coolers had residue/build-up in the reservoir. These reservoirs are designed to catch excess water during operation and should be emptied/cleaned regularly to prevent microbial and/or bacterial growth.

Other Concerns

Several other conditions that can potentially affect indoor air quality were identified. Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the building, MDPH staff obtained measurements for carbon monoxide.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address airborne pollutants and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the USEPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the building were also ND.

A number of other conditions were noted during the assessment, which can affect indoor air quality. Filters in the rooftop AHUs and return vents in the NFD were examined and found coated with dirt/dust and accumulated material (Pictures 20 and 21). A debris-saturated filter can obstruct airflow and may serve as a reservoir of particulates that can be re-aerosolized and distributed to occupied areas via the ventilation system.

Occupants expressed concern over the dirt/dust accumulation on carpets and floors in offices and hallways. Also of note was the amount of materials stored in some areas. In many areas, items were observed piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. Also, dust becomes more readily aerosolized in a low relative humidity environment. For these reasons, items should be relocated and/or cleaned periodically to avoid excessive dust build up.

Carpeting in several areas was extremely worn and damaged. Occupants reported that the majority of carpeting was installed in the late 1980's, which would make them over 20 years old. Disintegrating textiles can be a source of particulates, which can be irritating to the eyes, nose and throat. Carpet fibers/particulate matter can also be entrained and suspended in the air by the mechanical ventilation system.

Finally, exposed fiberglass insulation was observed around ductwork in the Recreation Department (Picture 22). Fiberglass insulation can be a source of skin, eye and respiratory irritation to sensitive individuals.

Conclusions/Recommendations

The conditions related to indoor air quality problems at the NMC raise a number of issues. The general building conditions, maintenance, work hygiene practices and the condition or lack of HVAC equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further degrade indoor air quality. Some of these issues can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons, a two-phase approach is required for remediation. The first consists of **short-term** measures to improve air quality and the second consists of **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns.

The following **short-term** measures should be considered for immediate implementation:

1. Remove and replace any mold contaminated/water damaged GW, wooden baseboard/trim and carpeting in the basement. This measure will remove actively growing mold colonies that may be present. Remove mold contaminated materials in a manner consistent with recommendations found in "Mold Remediation in Schools and Commercial Buildings" published by the US Environmental Protection Agency (US EPA, 2001). Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.
2. Contact an HVAC engineering firm to clean out and make necessary repairs to the casing of the large rooftop AHU.
3. To maximize air exchange, operate ventilation systems throughout the building continuously during periods of occupancy independent of thermostat control.
4. Operate thermostats in the fan "on" setting during occupancy to provide continuous air circulation.
5. Remove blockages (i.e., plastic sheeting) from supply vents.
6. Work with the Town's HVAC vendor to make adjustments to the mechanical ventilation system to improve the comfort of occupants.
7. Consider balancing mechanical ventilation systems every 5 years, as recommended by ventilation industrial standards (SMACNA, 1994).
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped

vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g. throat and sinus irritations).

9. Ensure any roof/plumbing leaks are repaired. Replace any missing and/or water-damaged ceiling tiles and examine the area above and beneath these areas for microbial growth. Disinfect areas of water leaks with an appropriate antimicrobial. Clean areas of antimicrobial application when dry.
10. Examine black spots in corner of Treasurer's Office to confirm if they are open utility holes. If so, seal the holes with a proper material.
11. Seal open holes/breaches on exterior of the building to water intrusion drafts and/or pest entry.
12. Clean and disinfect dehumidifiers/humidifiers as per the manufacture's instructions to prevent microbial growth.
13. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
14. Relocate or place tile or rubber matting underneath water coolers in carpeted areas. Clean and disinfect reservoirs as needed to prevent microbial growth.
15. Clean/change filters for all air handling equipment in the NTH and NFD as per the manufactures' instructions or more frequently if needed.
16. Clean supply/return vents periodically of accumulated dust.
17. Wrap/cover fiberglass insulation material around ductwork in Recreation Department.
18. Relocate or consider reducing the amount of materials stored in common areas to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

19. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

The following **long-term measures** should be considered:

1. Contact an HVAC engineering firm for an assessment of ventilation systems building-wide (e.g., controls, air intake louvers, thermostats). Based on the age, physical deterioration and availability of parts for ventilation components, such an evaluation is necessary to determine the operability and feasibility of repairing/replacing the equipment.
2. Consider total carpet replacement or the replacement of carpeting with an alternative floor covering.

References

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OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

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SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

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Picture 1

Norton Town Hall

Picture 2

Norton Municipal Center, Norton Fire Department on Left, Town Hall on Right

Picture 3

Small Rooftop AHU

Picture 4

Large Rooftop AHU

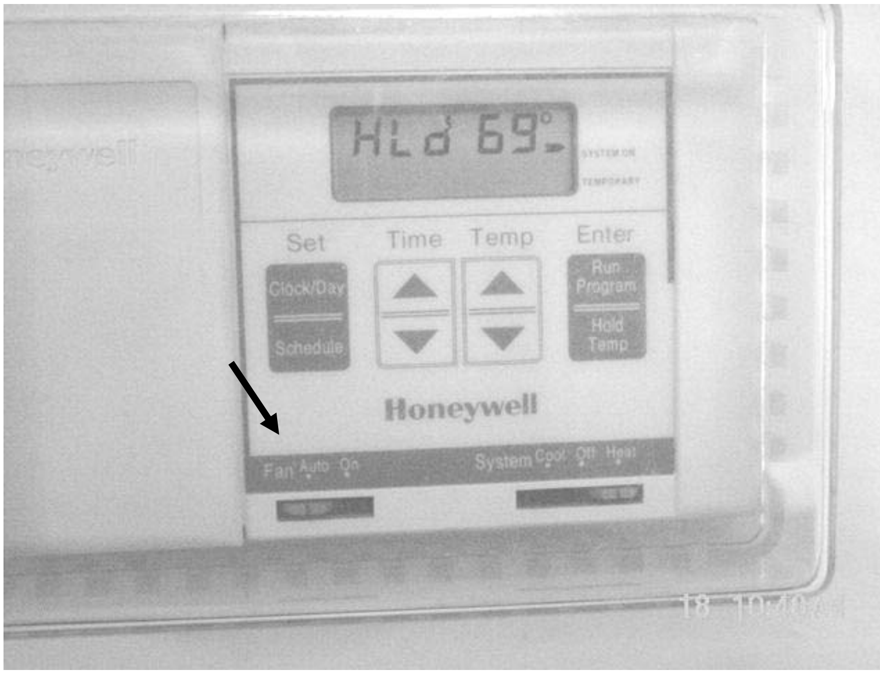
Picture 5

Ducted Supply and Return Vents

Picture 6

Grated Supply Vent

Picture 7

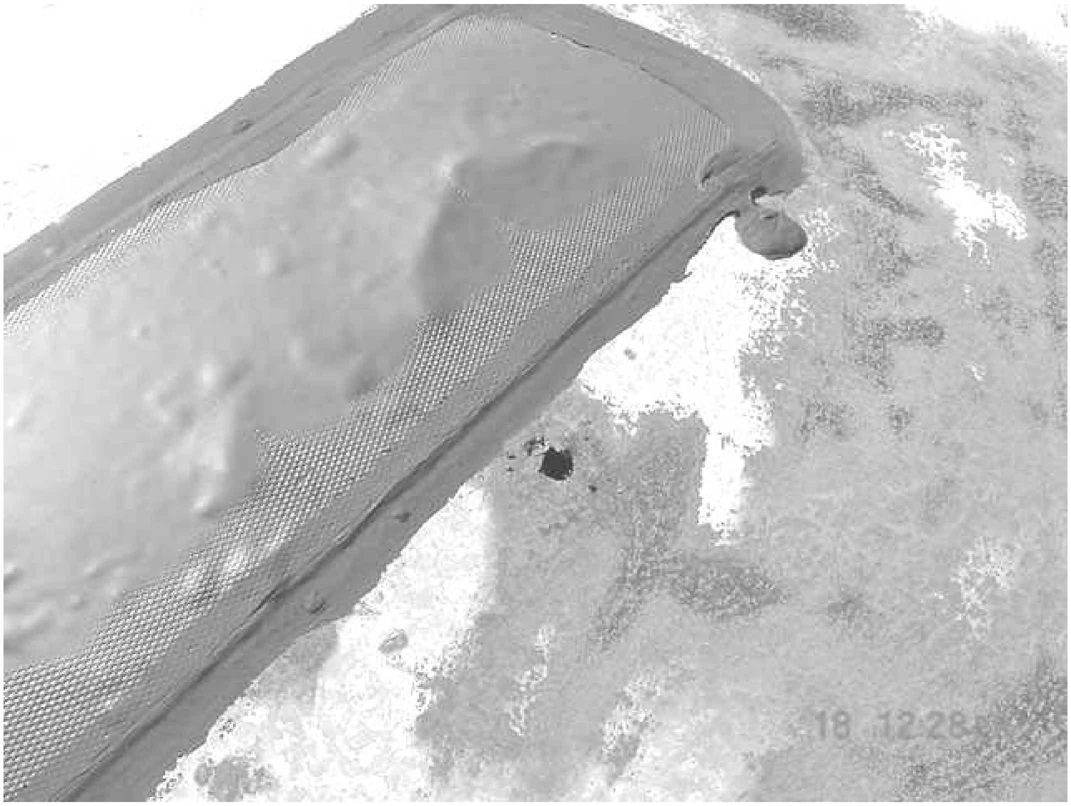


Thermostat for HVAC System, Note Fan Switch to "Auto" Setting

Picture 8

**Top View of Large AHU Note Corrosion Indicated by Dark Areas,
Also Note Patches Indicated by Arrows**

Picture 9



Close-Up of Corrosion and Patch on Top of Large AHU Casing

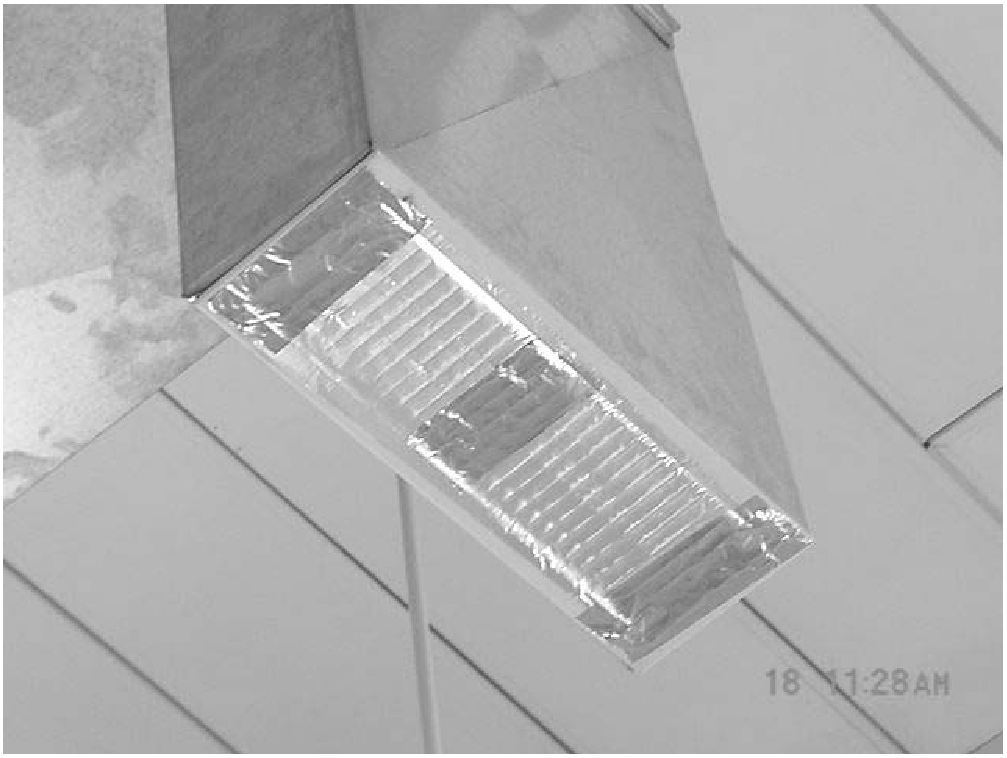
Picture 10

Damaged Access Panel and Corrosion on Side of Large AHU Casing

Picture 11

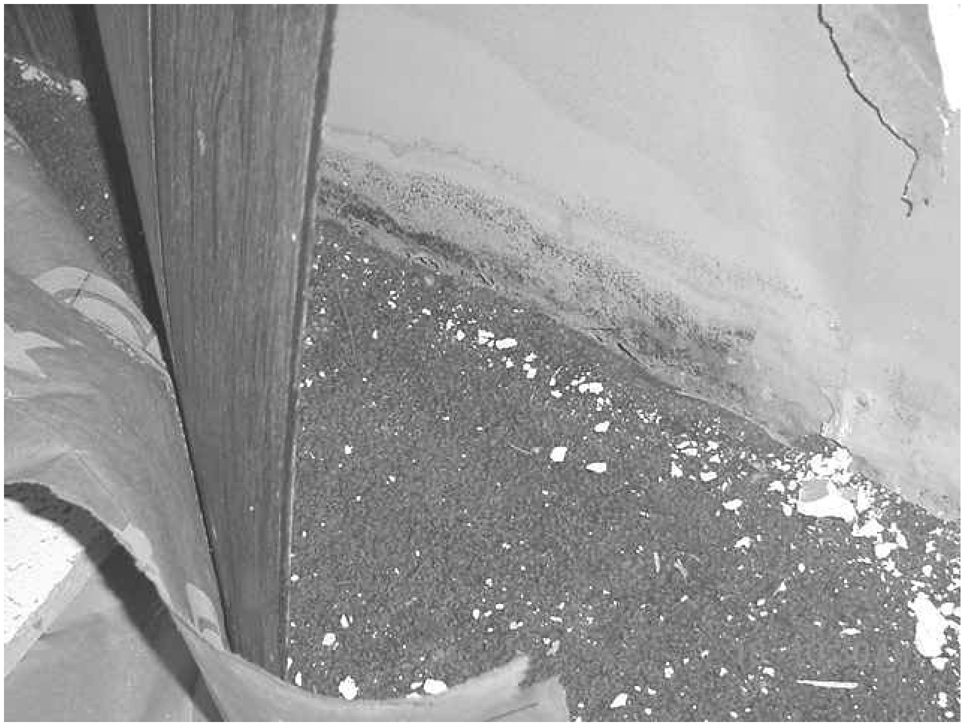
Large Open Former Gymnasium Area that Houses the Treasure's Office, Note Semi-Enclosed Second Level

Picture 12



Supply Vent Sealed with Plastic and Duct Tape

Picture 13



Mold Growth on GW and Musty Carpeting in Unoccupied Basement (Former Police Department Area)

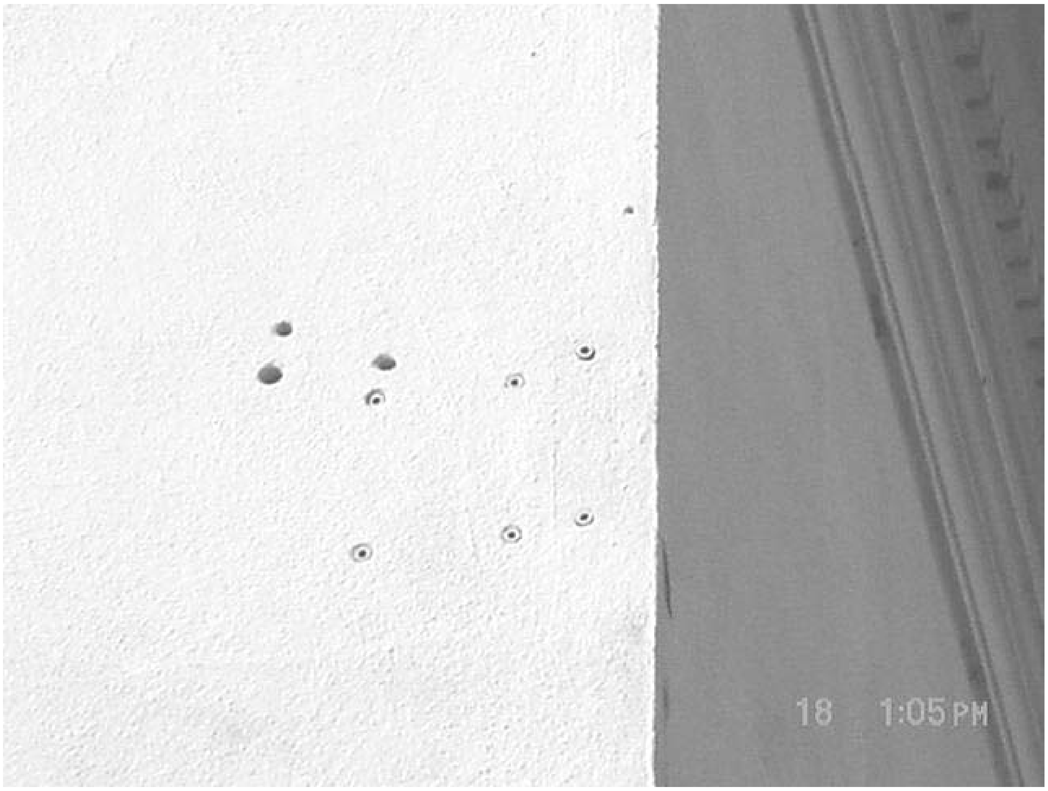
Picture 14

Dirt, Dust and Debris inside Large AHU

Picture 15

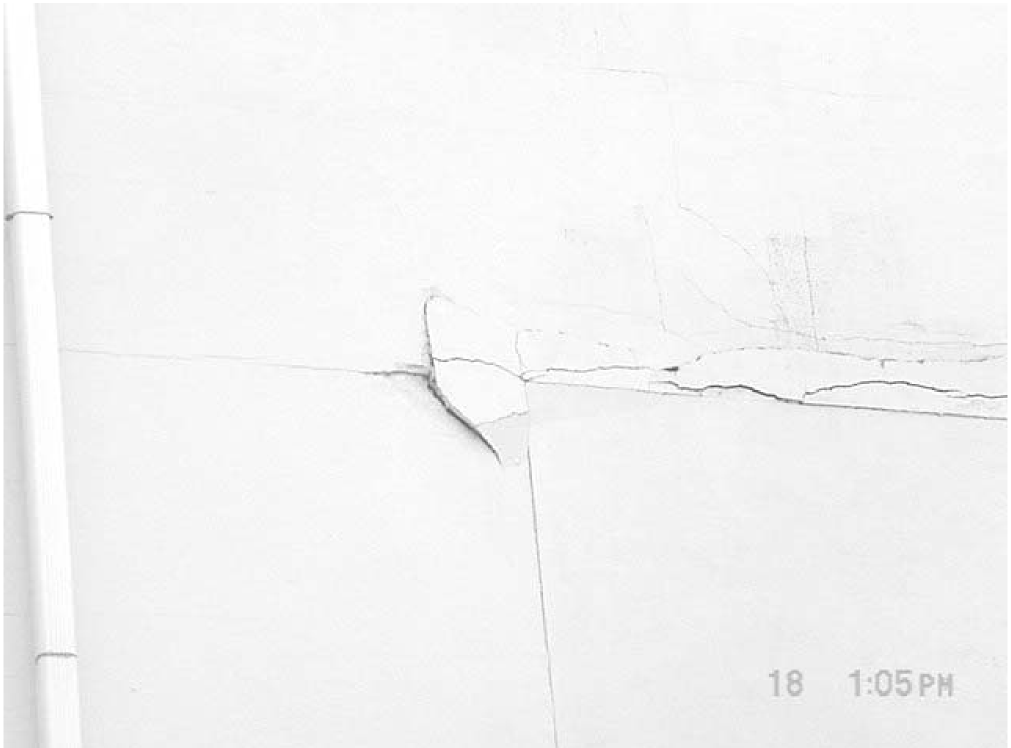
Black Spots in Corner of Treasure's Office

Picture 16



Holes on Exterior of Building Opposite "Black Spots" in Treasure's Office

Picture 17



Breach on Exterior Wall Material

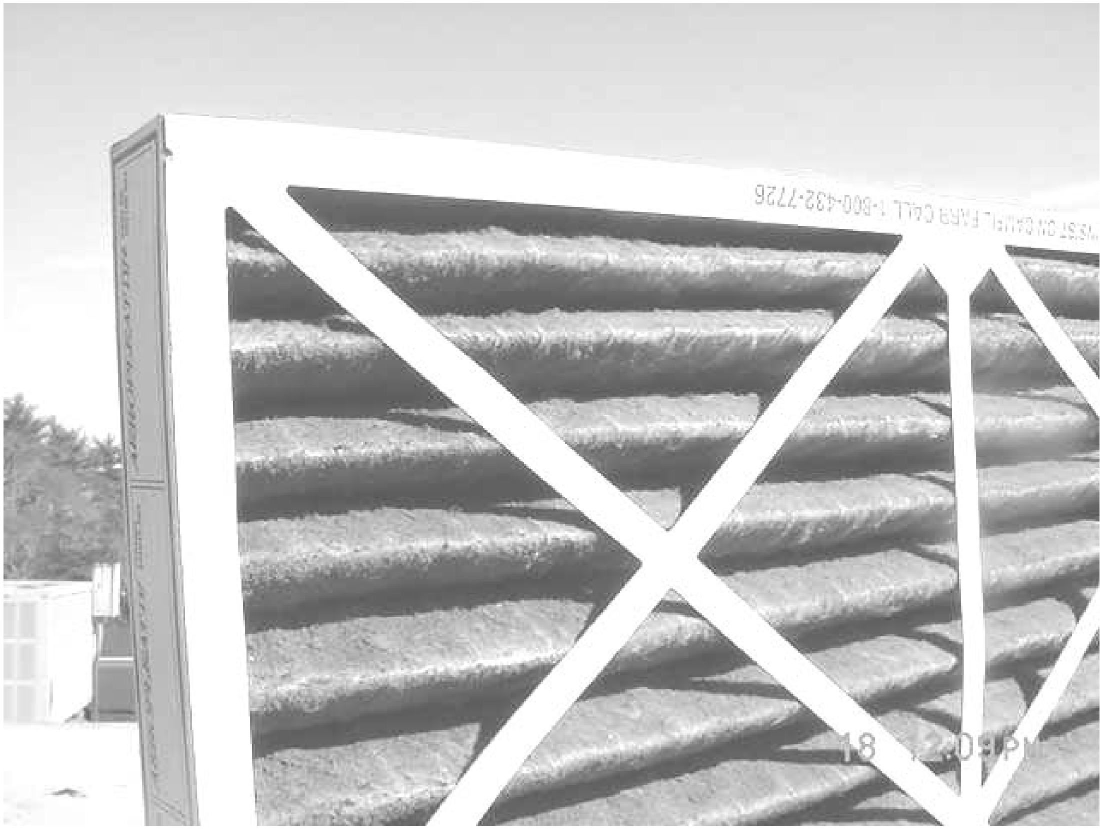
Picture 18

Water Damaged Ceiling Tiles in NTH

Picture 19

Water Damaged Ceiling Tiles in NFD Union Office

Picture 20



Debris Saturated Filter in Large AHU

Picture 21

Ceiling-Mounted Return Vent in the NFD Completely Occluded by Dirt, Dust and Debris

Picture 22

Exposed Fiberglass Insulation around Ductwork in Recreation Department

TABLE 1

Indoor Air Test Results – Norton Town Hall — February 18, 2005

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
Outside (Background)	333	ND	42	32					Partly Cloudy
Basement room next to photo lab	478	ND	62	27	0	N	N	N	Mold growth on base of wall near carpeting-odors
Storage Room	386	ND	61	26	0	N	Y	Y	Carpet dirty
Town Manger Area	522	ND	65	29	0	Y	Y	Y	Ceiling fan-on, open floor plan
Selectman's Office	563	ND	66	28	1	N	Y	Y	Thermostat fan "auto"
Town Manager Office	581	ND	68	24	0	Y	Y	Y	
Accounting Reception	618	ND	68	25	2	Y	Y	Y	
Accounting Office	570	ND	69	25	1	Y	Y	Y	Plants, temperature control issues (heat)
Treasurer/Collector Main Frame Room	608	ND	71	23	0	N	Y	Y	Missing CTs

- **ppm = parts per million parts of air**
- **ND = non detectable**
- **WD = water damage**
- **CT = ceiling tiles**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Table 1-1

TABLE 1

Indoor Air Test Results – Norton Town Hall — February 18, 2005

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Treasure's Office	624	ND	72	22	7	Y	Y	Y	Reports of mold in corner/wall
Town Clerk	631	ND	72	22	5	Y	Y	Y	Open floor plan, supply vent sealed
2nd Floor									Abandoned water fountain
Planning Board	599	ND	71	22	5	Y	Y	Y	WD CTs, water fountain on carpet
Recreation Dept.	594	ND	71	23	2	Y	Y	Y	Exposed fiberglass insulation
Assessors Office	588	ND	72	23	3	N	Y	Y	Humidifiers
Board of Health	560	ND	79	28	0	N	Y	Y	Temperature extremes-heat, humidifier
Fire Department (FD) Union Office									WD CTs (10)
FD Lounge	745	ND	70	26	5	Y	Y	Y	1 CT

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FD Living Quarters	654	ND	66	26	0	Y	Y	Y	Dust accumulation filters on return vents, air diffusers and grills
Roof Notes									Large AHU-corroded metal casing, filters dirty, damaged access panels
Perimeter Notes									Breaches in exterior wall upper east side, holes in south east corner corresponding to dark areas in Treasurer's Office, wasps nests roof eaves

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